Command and Control Assessment using the German Simulation System FIT

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ABSTRACT

*The simulation system FIT ("**F**ührung und **I**nformations-**T**echnologie" = Command and Control and Information Technology) was defined and implemented to meet the requirements of the analyses of command, control, and communication.*

The paper gives an overview of the simulation system as well as its application for the assessment of different command and control means, systems, and organizations and also communication facilities, installations, and systems.

To analyze the interaction between the C2 & CI structure and the outcome on the battlefield FIT can be federated with existing combat and recce simulation systems.

***Key Words**: Command, Control, Communication, Situation Map, Decision Making, Workflow in CPs.*

1.0 INTRODUCTION

The German simulation system FIT (*"Führung und Informations-Technologie"*) comprises models to cope with command and control (C2) organizations, C2 procedures, and C2 means, including communications. Therefore, it can be used as a stand-alone systems as well as a C2 & CI federate within embedding combat or reconnaissance simulation.

FIT has been design to meet the requirements of the German Army within the domain of command and control and C2 support to:

- Analyze and Evaluate the influence of evolution and progress of C2- and CI-systems
- Support the Planning of C2 for specific operations
- Model and Analyze Operations of C2- and CI-systems during missions.

The warfighter, armed forces offices, schools, as well as respective procurement agencies can be supported by conducting the necessary operational analyses. The application also can bridge the gap between the warfighter and the procurement office, developers and implementers in industry, planers and operators. By taking into account the different requirements and making the interdependencies obvious in respective simulation runs, the different stake holders get a more holistic view of the C2 problem and the influence of their decision than it would be the case without such a common tool. The German Army Office (*"Heeresamt"*) therefore distributed the system to potential users within the Department of Defense, the Army Office, and Schools of the Army.

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Within the domain "Training and Exercises" the FIT system is planned to be used as a computer assisted exercise (CAX) tool for command and control support troops. It is planned to use the system:

- in stand alone versions at the respective school,
- embedded in a closed combat simulation to be able to train within a synthetic operational environment comprising all relevant forced (simulated), as well as
- embedded in the overarching CAX system of the army to be trained together with forces to support.

Within the domain of "Support to Operations" there is a twofold use of the FIT system:

- FIT can be used for full mission rehearsals and extensive C2 after action analyses, including what-if analyses and online support for C2 improvement.
- FIT can be used for the implementation of realistic command agents to be used for adequate generation of orders for the simulated forces in closed combat simulation systems to be used for alternative courses of action analyses.

2.0 (GE) COMMAND AND CONTROL PROCEDURES

The exercise of command that is the process through which the activities of a military force are directed, coordinated, and controlled to accomplish the mission. This process encompasses the **personnel, equipment, communications, facilities**, and **procedures** (C2 System) necessary to gather and analyze information, to plan for what is to be done, and to supervise the execution of operations.

The Command and Control (or Troop Leading) Cycle is a sequence of activities which comprises the following for phases:

- Assessment of the Situation
- Planning
- Issuance of Orders
- Control

Assessment of the situation is concerned with **gathering**, organizing, storing, presenting, comparing, **analyzing**, and evaluating information with respect to the own and enemy situation. The assessment of the situation ends with a **statement about the situation of the enemy**, the own troops, and the environment.

The **estimate of the situation** as the first step in the planning phase prepares the decision. All circumstances of the situation affecting the realization of the given order are analyzed and evaluated. The resulting **possibilities for alternate courses of action** are balanced against each other. This consideration of all factors related to an issue involving alternate courses of action arrives at a **decision** for a line of action intended to be followed by the commander as the one most favorable to the successful accomplishment of his mission. The operational plan shows (e.g. graphically) how the commander wants to employ his forces and assets. The operational plan is also a tool for the control phase in the command and control cycle.

The **orders** resulting from the planning phase are given to the subordinates.

Subordinates report on changes in their situation (own and enemy) during execution of the given order. Depending on the kind of changes this will cause a new start of the C2 cycle.

From this description of the C2 procedure we can identify methods and objects which must be available in a simulation system for C2.

Making a decision is one job within headquarters or command posts. There are other jobs, e.g. plotting enemy situation and own situation, generating orders, and transmitting information. All these jobs take time and all these jobs are executed in a well defined organization.

3.0 GENERAL ARCHITECTURE (INPUT / OUTPUT)

The following example is designed to make the reader understand the general context of the model a little bit better.

Basic for the work in a Command Post are Messages, Orders, or Information which must come from outside of FIT for example a combat or a recce simulation system. This kind of data is mainly related to changes in positions, combat power and results of recce missions. Orders might also come from an interactive user working with FIT.

Beside the dynamical input data FIT needs the Hierarchical and Procedural Organization. Different types of command posts are developed with an editor and stored in a so called Command Post Data Base (CP DB).

The model “Command Post” includes all the functionality we discussed in the previous section.

The transmission of messages and orders but also information within the command post is part of the Communication Model. The technical capabilities of the communication means are stored in a DB.

As the transmission might be jammed or disturbed by the enemy or the terrain, FIT also needs as an Input Information related to the terrain.

The output from FIT can be analyzed by itself but might also be used as an Input by a Combat Simulation System or a Reconnaissance Simulation System.

The combat simulation model gives changes of the states and results from reconnaissance missions from all employed elements as an input to FIT.

In the opposite direction the aim is to give orders or information requests to the linked simulation model.

Technically this coupling is realised as the exchange of files for two separate programs running in parallel on the same computer or via a network software (RTI based on HLA).

4.0 APPLICATIONS

The FIT system is well suited to deal with a great set of questions concerning command, control, and communication on various levels. The following fields of interest have been identified within discussion with the warfighters as well as within respective conceptual studies that now can be supported by qualitative analyses using FIT.

4.1 Command and Control Analyses

- Time constraints concerning command and control as well as command support.
- Comparison of ground truth and perception taking into account the usable information.

- Comparison of available information and needed information (necessity for better ISR means or improved ISR planning).
- Availability of information, including reliability, fidelity, timeliness, etc.
- Evaluating the effect of information operations over the whole spectrum.
- Evaluating the influence of additional means of command and control – e.g. decision support systems – on the improvement of the command process (time and quality).

4.2 Communications Analyses

- Analyzing and optimizing the information relations for various scenarios.
- Comparison of capacity and number of reports and orders.
- Evaluating the redundancy within the information flow.
- Evaluating the influence of communications on combat operations.
- Evaluating the introduction of new technologies on the information flow (e.g., introducing GPS for every system to reduce the location messages and thereby providing no longer used resources/ bandwidth for other messages).

4.3 Information Processing

- Impact of support means upon CI-systems.
- Impact of countermeasures.

5.0 THE FIT ARCHITECTURE

5.1 Modeling Command Posts

The main requirement for the modeling of the command and control process was the possibility to model different types of headquarters and command posts.

This following figure gives You a High Level Diagram for the modeling of Command Entities:

- A Command Entity may have a Command Post
- A Command Post may have one or more Cells
- A Cell is built by a Combat Entity; whereby the Cell gets position and vulnerability
- There may be Combat Entities not having built a Cell

A Cell consists of Methods:

- Situation Map,
- Decision Making,
- control the internal workflow and a
- for Information Interchange,
- and of one or more Communications Means.

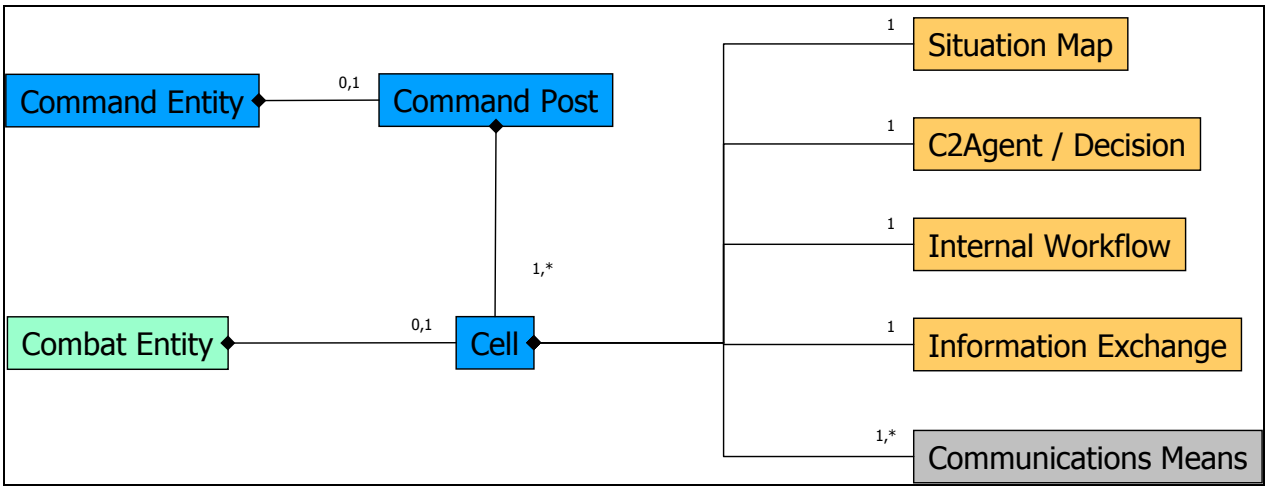

Figure 1: Modeling Command Posts.

5.2 Methods for Command Post / Cells

The following first two subsections deal with information processing, while subsection 3 and 4 are related to information transmission.

The actual influence of the information processing is actually limited to time delays, as no other specifications of effects to be implemented in a simulation systems could be given by the stakeholders. The time needed to execute a given task depends on the capacity of the command post respective the active cells. If the resources are already engaged in another process, the actual task has to wait for free capacities. If there is a bottleneck, the tasks will queue up which will be displayed and can be further evaluated.

5.2.1 Situation Map

Every command post has its own individual perception of the situation. Reports, orders, and information exchanges with the neighbors can be used to update this perception. Additionally, own sensors may be used to fill the gaps. As not only technical aspects can be taken into account, but also organizational aspects of the hierarchy within a command post (by modeling respective constraints within the workflow or when assigning the resources to the tasks), the evaluation beyond purely technical aspects becomes feasible.

The Module “Situation Map” is responsible for:

- check Consistency on Inputs
- update Tables (Combat Power, Needs,...)
- aggregate Enemy & Own Situation
- generate Enemy & Situation Rep
- give known Situation to Decision-Making

5.2.2 C2 Agent / Decision Making

The C2 Agent determines Orders for Subordinates, depending on the own Order, the capabilities of Subordinates, and the known situation (enemy and own forces).

Figure 2 gives an example for a C2 Agent. The red mechanized Company is given the order to attack an objective by tying to avoid contact with blue forces. The C2 Agent determines the course taking into account the terrain and the known situation. On its way to the objective to red company is attacked by a blue company. This blue company wasn't in the situation map of the red company before. This is a dramatic change of the situation for red and the C2 Agent determines a new course, remember part of the order was to avoid enemy contact.

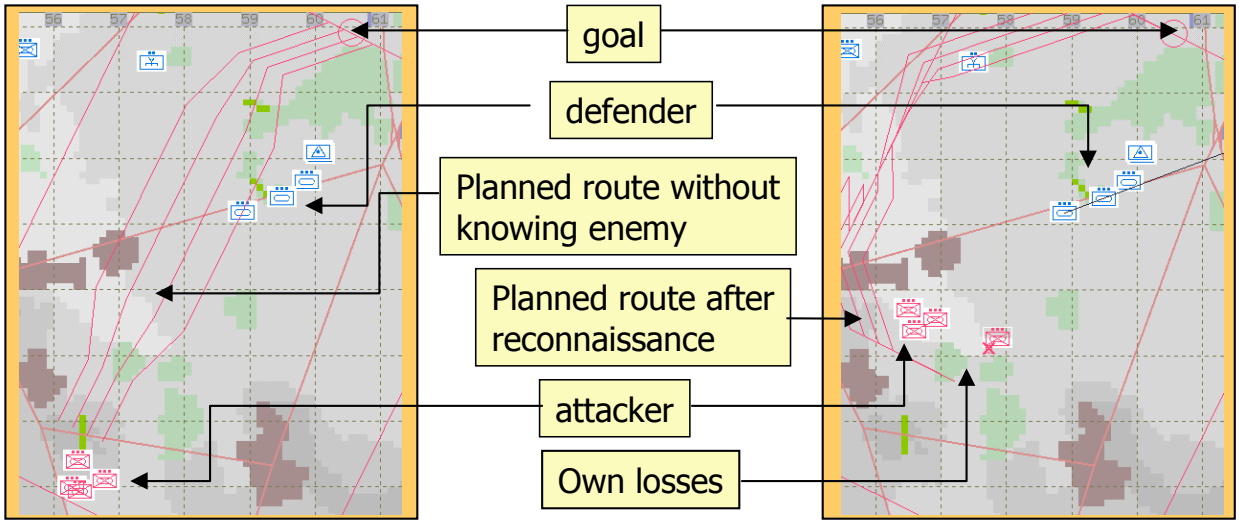

Figure 2: The C2 Agent "Attack".

5.2.3 Internal Workflow

The inner information structure of a Command Post (between Cells) is defined in form of resource dependent workflow. The internal workflow:

- controls the flow of information and activities within a CP
- initiates activities
- activates resources
- models the time needed for activities and
- models queues.

5.2.4 Information Exchange

However, there is not only an information flow between the cells of a command post. As already mentioned, every command post can send and receive reports and orders. In order to model this properly, a communication network has to be established. Within the FIT system, different and various communication means can be used: radios (broadcast as well as directional messages), digital links, telephone, telex, etc.

Based on their technical data a communication network is established enabling the information flow needed between the command posts. There may be several information transfer solutions between two points. It is part of the underlying decision logic of the chosen procedures to optimize the sharing of information.

For all command posts that share an information exchange requirement (IER), the communication means can be defined in detail via input parameters. Usable channels, bandwidth, capacity constraints, maximum

distance, influence of the terrain (e.g., line-of-sight limitations) can be configured individually for every IER.

- Who sends information to Whom?
- What kind of information? (Orders / Requests / ENEMYSITREP / OWNSITREP)
- When?
- Type / Setting / Load of Communications Means.

5.3 Architecture

The hierarchy of the command and control organisation which is employed in a given scenario is part of FIT. It is important for FIT that within the force structures also the headquarters with the staff elements and the communication personnel is contained.

The staff elements than can build, dismantle, and deploy command posts for their headquarters.

The signal corps establishes and maintains the communication lines between command posts and within the command posts. For this it is necessary to determine the (logical) relationship between the cells of the command posts. That means to which other cells the information has to be transmitted. This is done automatically within FIT based on a direct comparison of input and output. If a cell A transmits a message which another cell B (within the same CP, a cell of the superior CP, a cell of an attached CP) can understand, FIT automatically establishes an information relationship between these two cells. The relations can be overwritten by the user.

Within the cells the main activities of command namely the Assessment of Situation, Planning (with Estimation of Situation, Decision), control of own and enemy situation, and the generation of messages are addressed. FIT takes into account the given hierarchical a procedural organisation, the time necessary and the man power and equipment available to perform these activities.

The transmission of Information is based on communication means with their technical data and actual state. The communication means are embedded in a technical communication network to determine lines of communication.

Figure 3 shows the overall architecture for FIT coupled to our simulation system for Surveillance, Reconnaissance and Target Acquisition, OSIRIS.

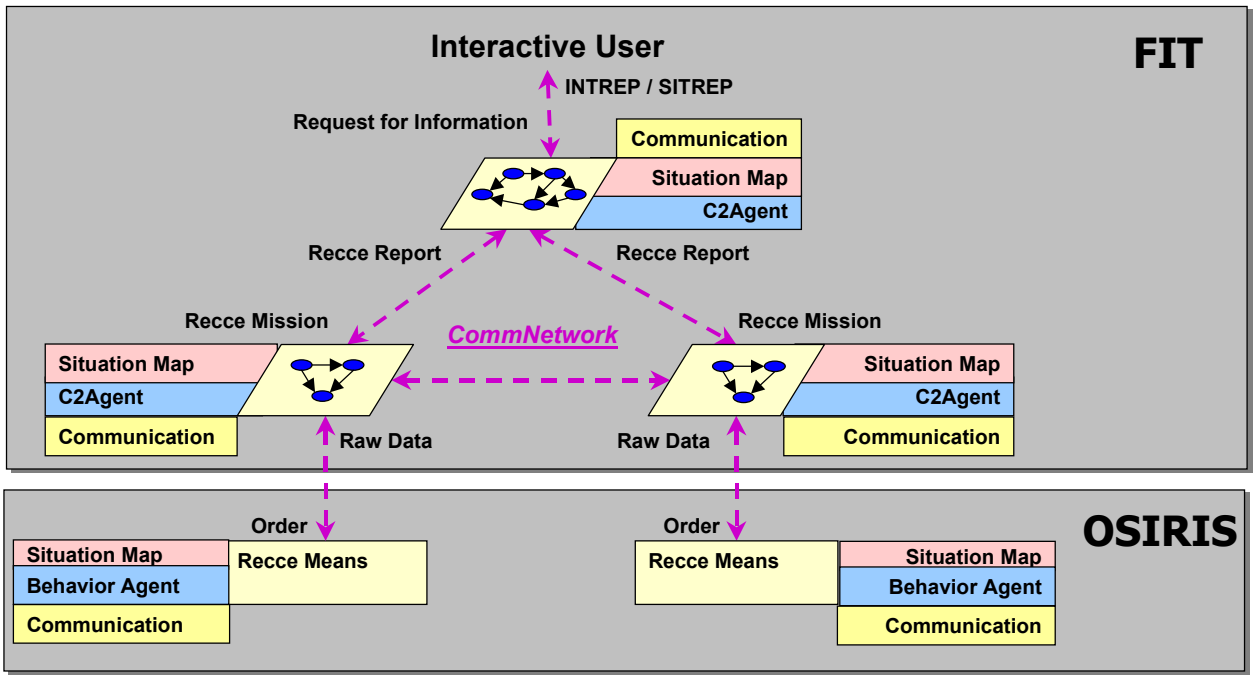

Figure 3: Architecture of the SimSys FIT.

5.4 Electronic Warfare and Information Operations

In the actual version, there are two ways to influence the FIT system.

On the one side, the connected combat or recce elements – i.e., the counterparts for command posts, cells, or communication means within the coupled simulation model – can be lethalized within the simulation. Within the FIT model, this would lead to the reduction of the respective capacity and resources. There is no attrition or suppression model in FIT, however, the reduction effect – i.e., a kill, suppression by the artillery down to 30%, etc. – can be calculated in the simulation model and handed over to FIT, where the influence of this reduction on the overarching command process is calculated.

On the other side, it is possible to use jammers to reduce the availability of information transfer means. A jammed frequency cannot be used for information transfer on neither side.

6.0 SUMMARY

To summarize, the FIT system enables the user to design command posts on all military levels in a very flexible way. It is also possible to model human behavior as well as group or organizational behavior implicitly as well as explicitly (team dependent time or efficiency constraints).

All simulated entities respective command agents, command posts, and headquarters have to share information. Within the FIT model, it is possible to model the interior as well as the exterior communication connections and means explicitly. The technical parameters of the communication means as well as environmental influences are taken into account. The communication model itself is again open, modular, and configurable.

In the moment, different radio types, satellite communications, Integrated Service Digital Networks (ISDN), and Local Area Networks (LAN) are modeled. The model takes the reports, messages,

situation perceptions, etc. to be communicated between the entities and evaluate time and quality of the transmission. This allows the modeling of electronic warfare as well as information operations.

As far as the evaluation of similar efforts showed, the German FIT system is unique in its complexity as well as offering functionality. As it is a full functional HLA federate, it can be adapted to every simulation system to be used as a command agent for analyses of command and control, as a helpful tool in computer assisted exercises for the OPFOR as well as for neighbored troops, and – last but not least – as command agents in simulation systems to be used as decision support systems.

On behalf of the German Army Office, the FIT system is actually distributed to the various potential users within the Offices of the Army, the Department of Defense, and various Schools of the Army. Objective of this effort is not only to test and validate the various aspects of the model, but also to get respective input parameters specifying the view of the problem of the various instances. This is the first time in the history of the German Army that a model based data collection and evaluation approach is conducted. Beside the reusable data, the German Army Office hopes to increase the quality of harmonization between the different views of the instances by introducing a common tool for structured analysis of the problem.

7.0 REFERENCES

[1] Dr. Andreas Tolk, Hans Jürgen Rech, Manfred Eberhard, *The German C3-Model FIT*, Paper 01F-SIW-011, 2001 Fall Simulation Interoperability Workshop (SIW), Orlando, Florida, September 2001.

[2] Manfred Eberhard, *Modeling of Command and Control*, Proceedings of the 39, Army Operations Research Symposium (AORS), Ft. Lee, Virginia, October 2000.

8.0 LIST OF ACRONYMS

CAX	Computer Aided Exercise
CP	Command Post
C2	Command and Control
CI	Communication and Information
DB	Data Base
FIT	Führung und Informations-Technologie
Recce	Reconnaissance

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IABG

C2 Assessment using the German SimSys FIT

Structure of the Presentation

- **General Ideas**
  - + Intention with a Simulation System for C2
  - + Command and Control Procedure
  - + General Architecture for a C2 & CI Simulation System
- **Description of the SimSys FIT**
  - + Modeling Command Posts
  - + Methods for a Cell
  - + Example for a C2 Agent
  - + Workflow for a CP
  - + SimSys Architecture
  - + Use of Communications Network
- **FIT Applications**
- **Summary**

C2 Assessment using the German SimSys FIT

Objectives

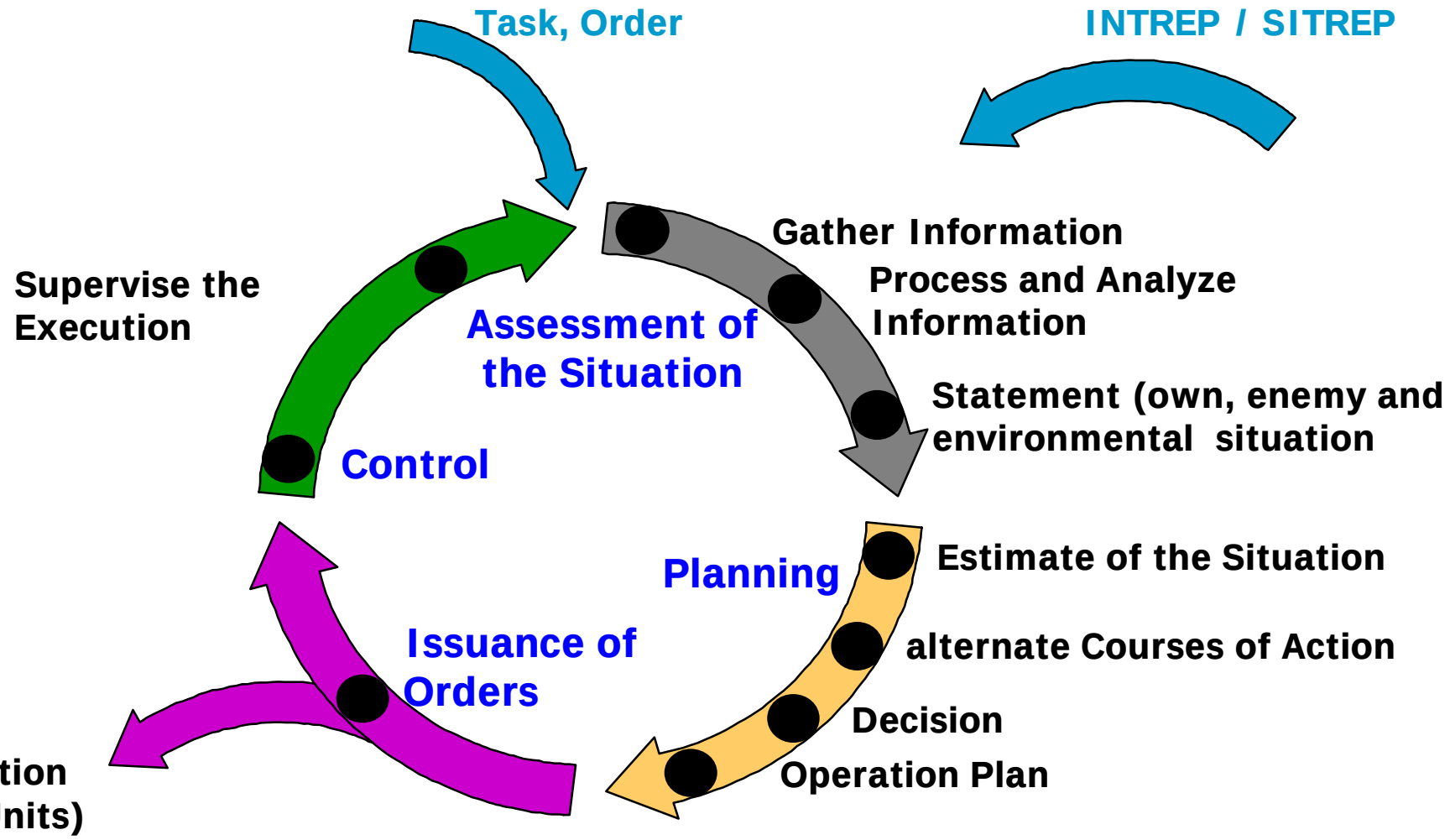
- Analyze and Evaluate the Influence of the Evolution of C2-Systems and CI-Systems
- Check and Verify Plans for specific Missions
- Model and Analyze Operations of C2-Sys and CI-Sys during Missions

- Train & Exercise
  Use of Simulation Technology (ST)
  in Command & Control

- Support to Operations
  Use SimSys and their Tools for C2

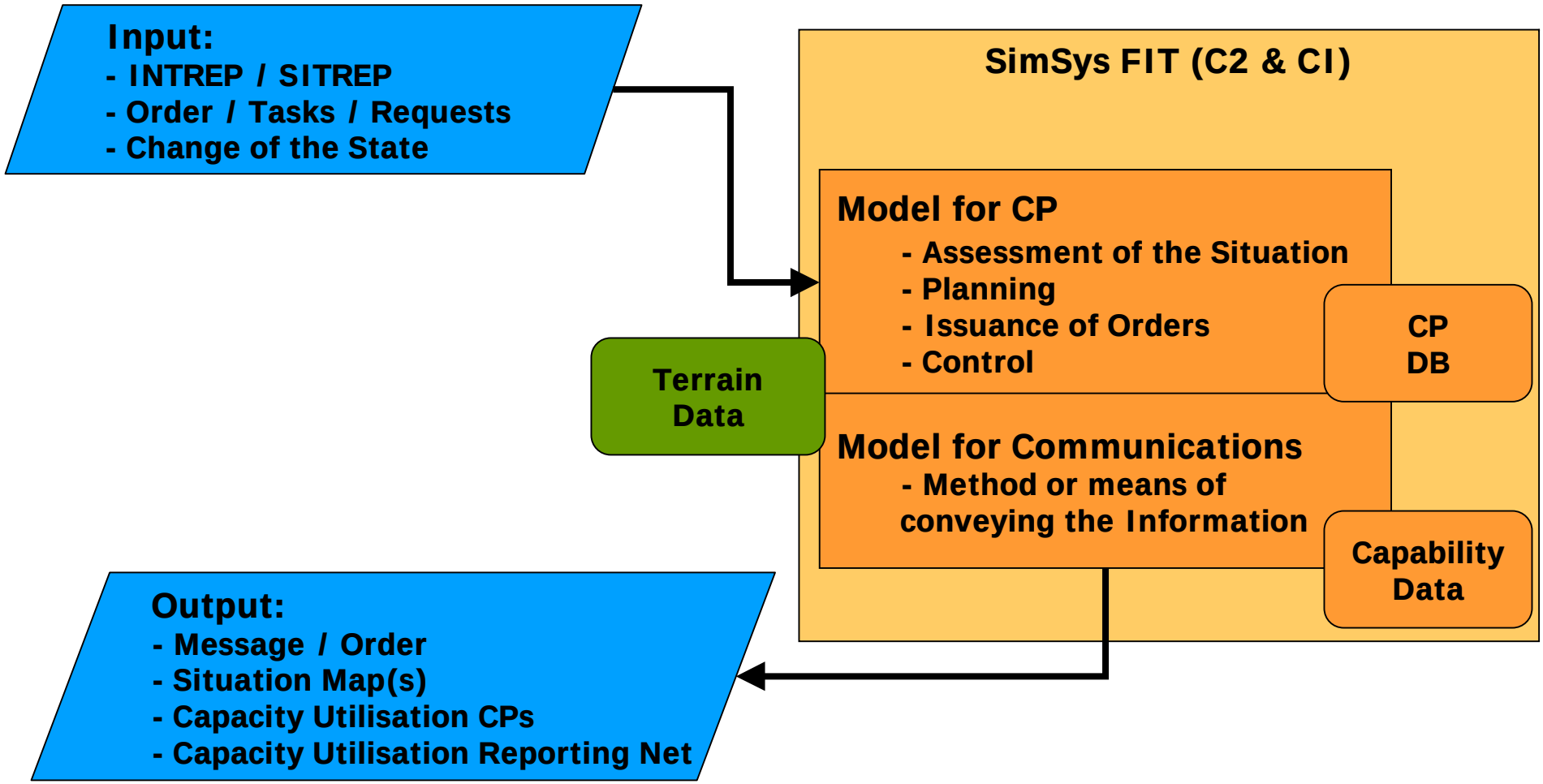
C2 Assessment using the German SimSys FIT

Command and Control Procedure



C2 Assessment using the German SimSys FIT

General Architecture (Input / Output)



C2 Assessment using the German SimSys FIT

Tasks in Areas of C2 & CI

Command and Control

- Dynamics of C2-Process / CI-support
- Availability of Information (timely, situational, detail, reliable)
- Efficiency of structural and process-oriented organization
- Impact of information processing upon C2-dynamics
- Impact of communication upon C2-dynamics

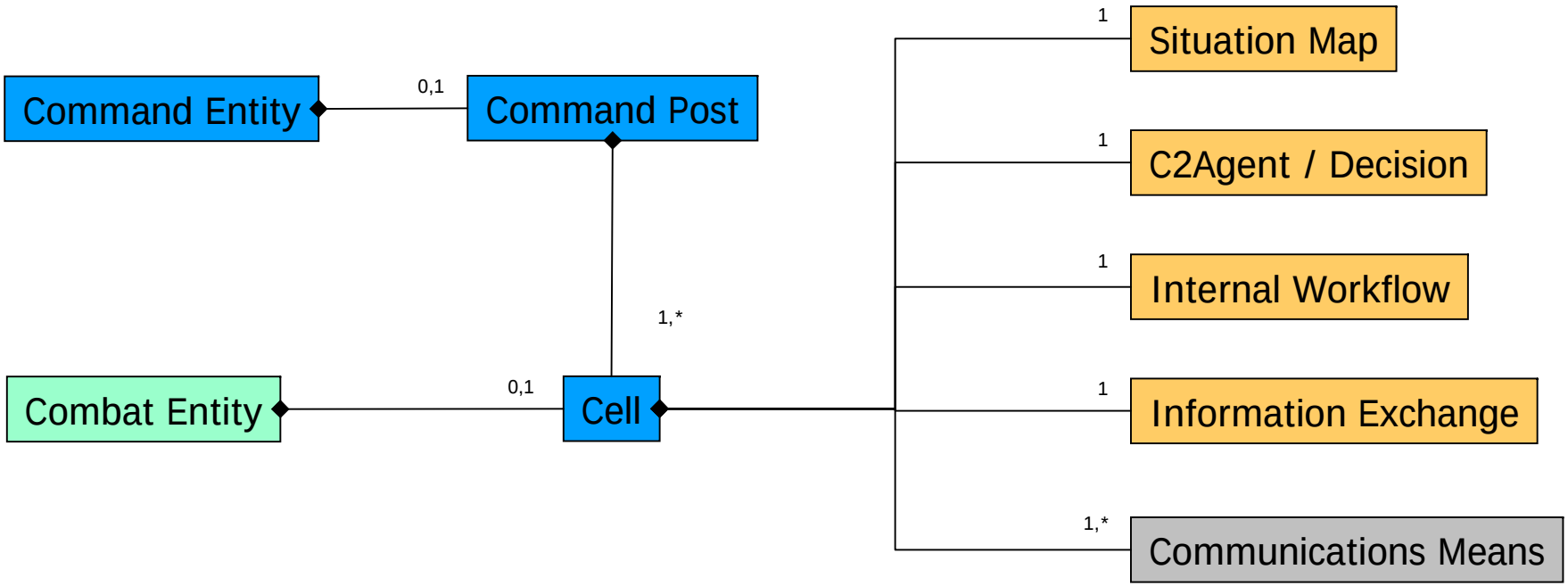
Information processing

- Impact of support means upon CI-dynamics
- Impact of countermeasures

Communication

- Impact of information relations and communication means
- Report loads vs.. transmission capacities
- Impact of countermeasures

Modeling Command Posts



C2 Assessment using the German SimSys FIT

Methods for a Cell

–Situation Map

+ check Consistency on Inputs
+ update Tables (Combat Power, Needs,...)
+ aggregate Enemy & Own Situation
+ generate Enemy & Situation Rep
+ give known Situation to Decision-Making

–Decision

+ determine Orders for Subordinates
+ depending on
  - Own Order
  - Capabilities of Subordinates
  - Known Situation (Enemy and Own Forces)

–Internal Workflow

+ control the Flow of Information and Activities within a Cell
+ initiate Activities
+ activate Resources
+ modeling the Time needed for Activities
+ modeling of Queues

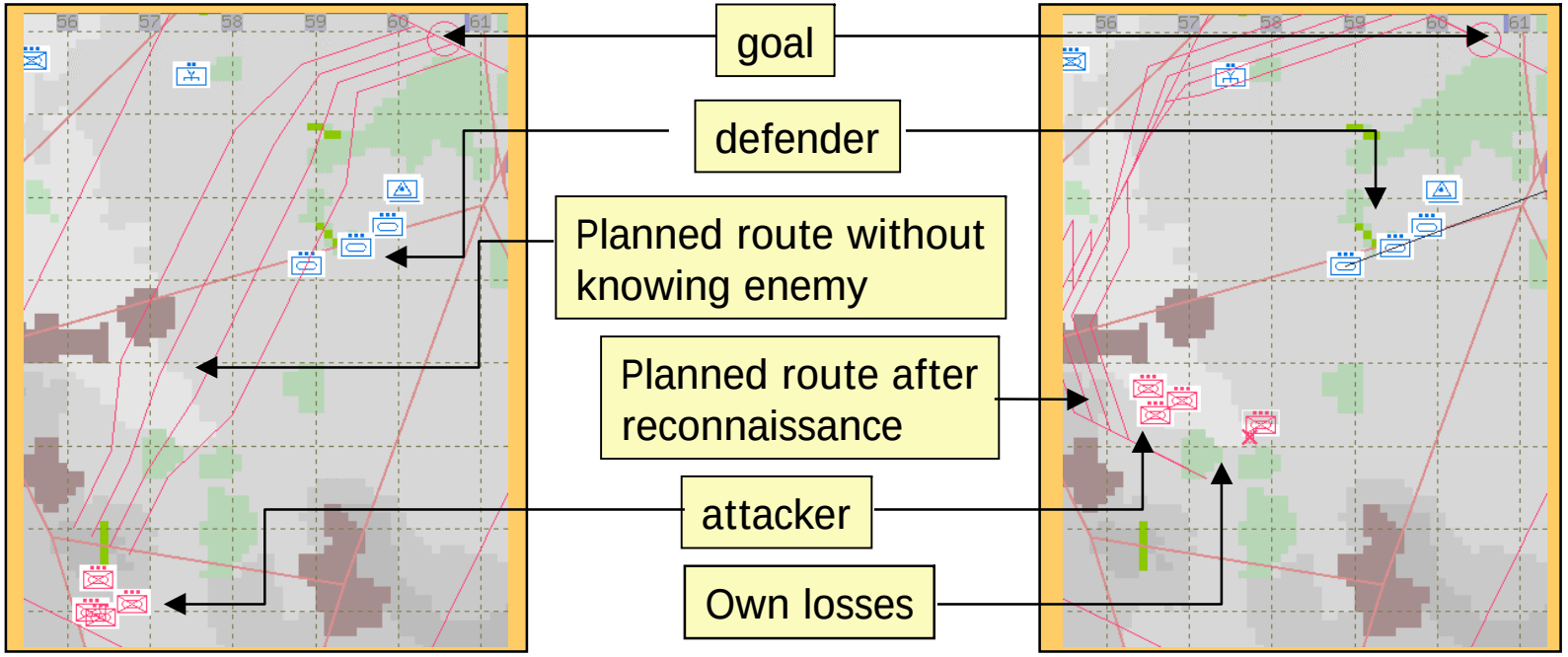
–Information Exchange

+ Who sends Information to Whom?
+ What Kind of Information?
+ When?
+ Type / Setting / Load of Communications Means

C2 Assessment using the German SimSys FIT

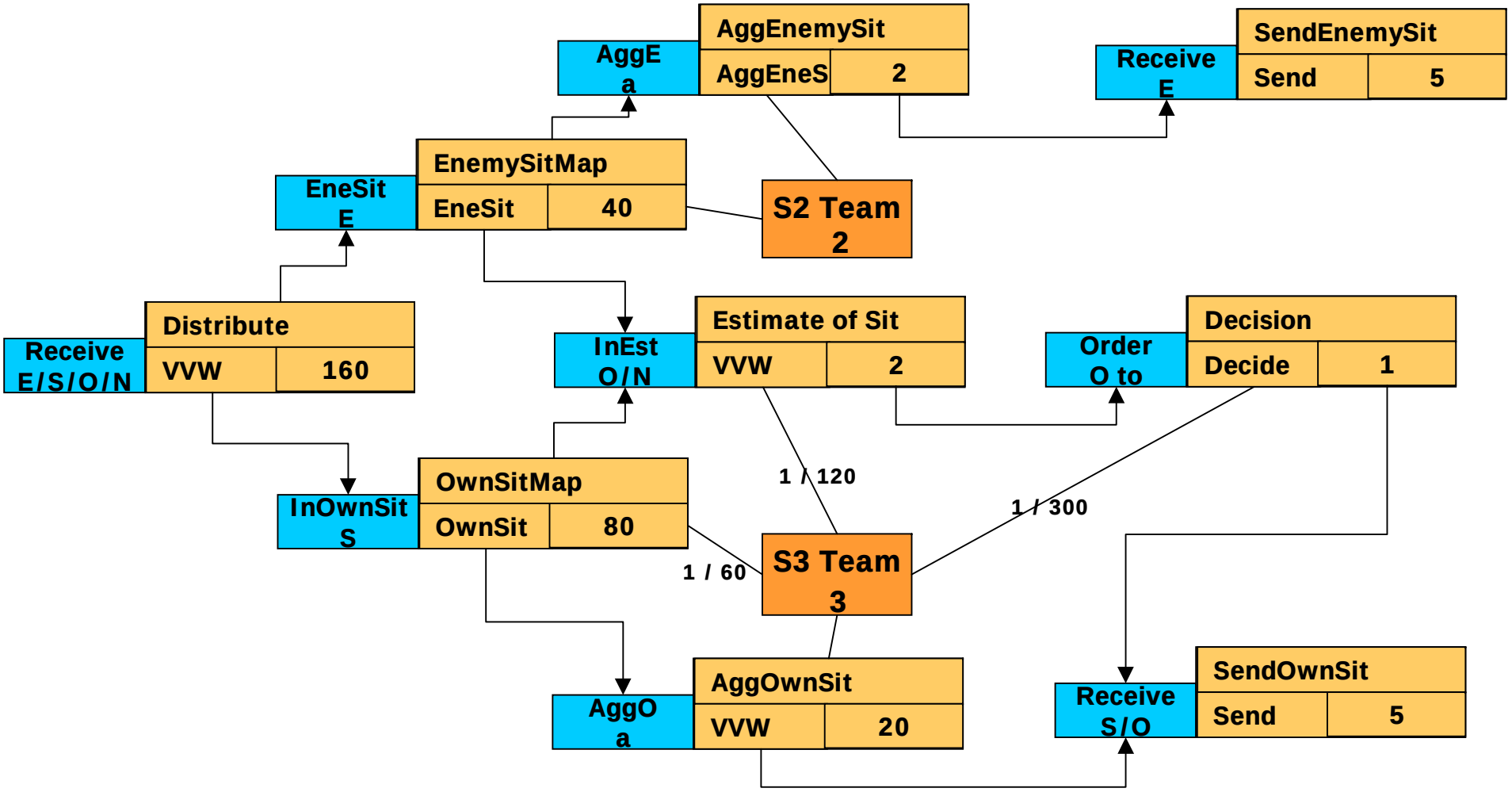
Example for a C2 Agent Attack

- Order: Objective and try to avoid Enemy Contact; ()
- Internal Data: different Formations, Off-Road-Network, “Costs”



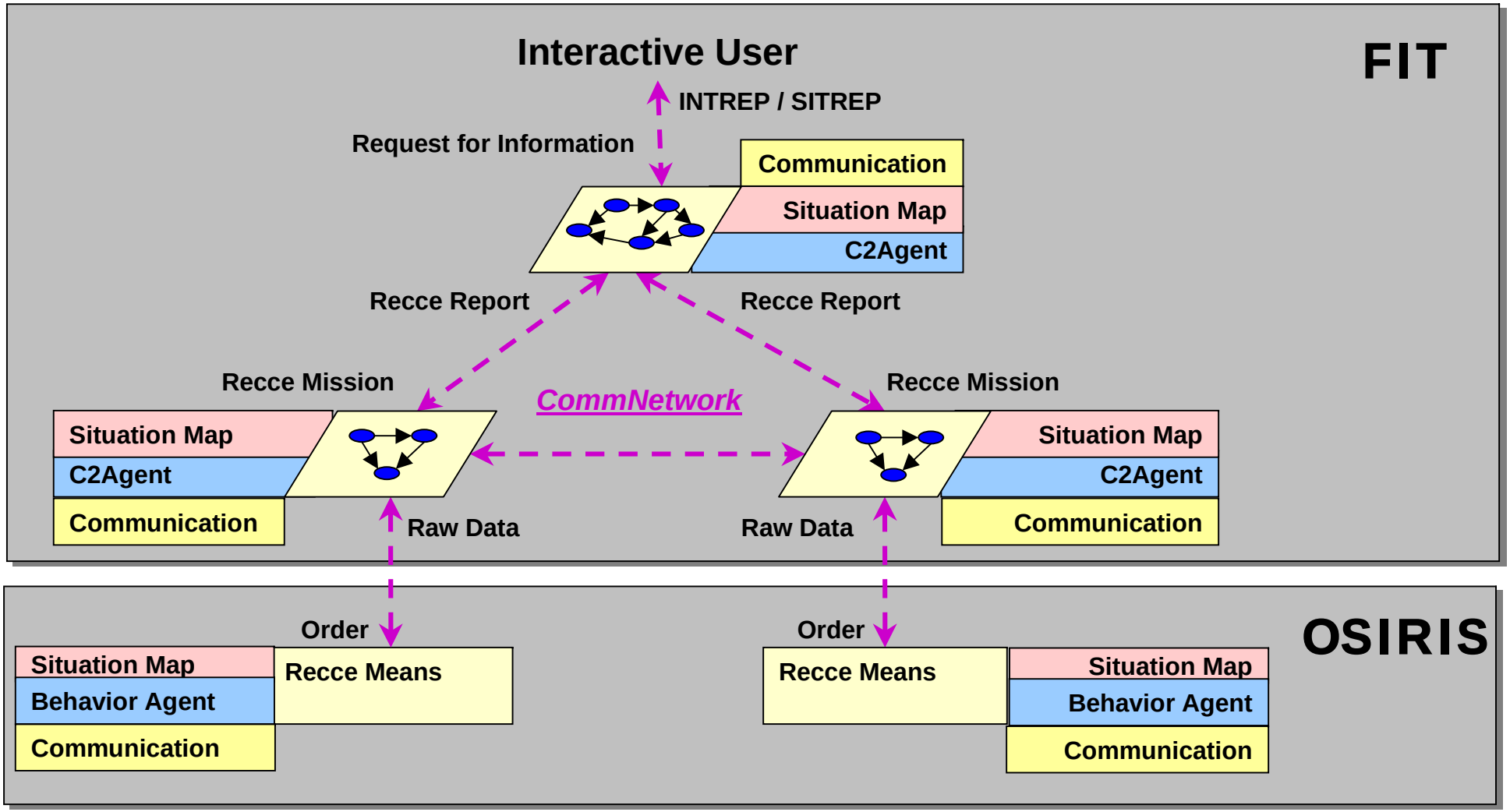
C2 Assessment using the German SimSys FIT

Workflow for a CP



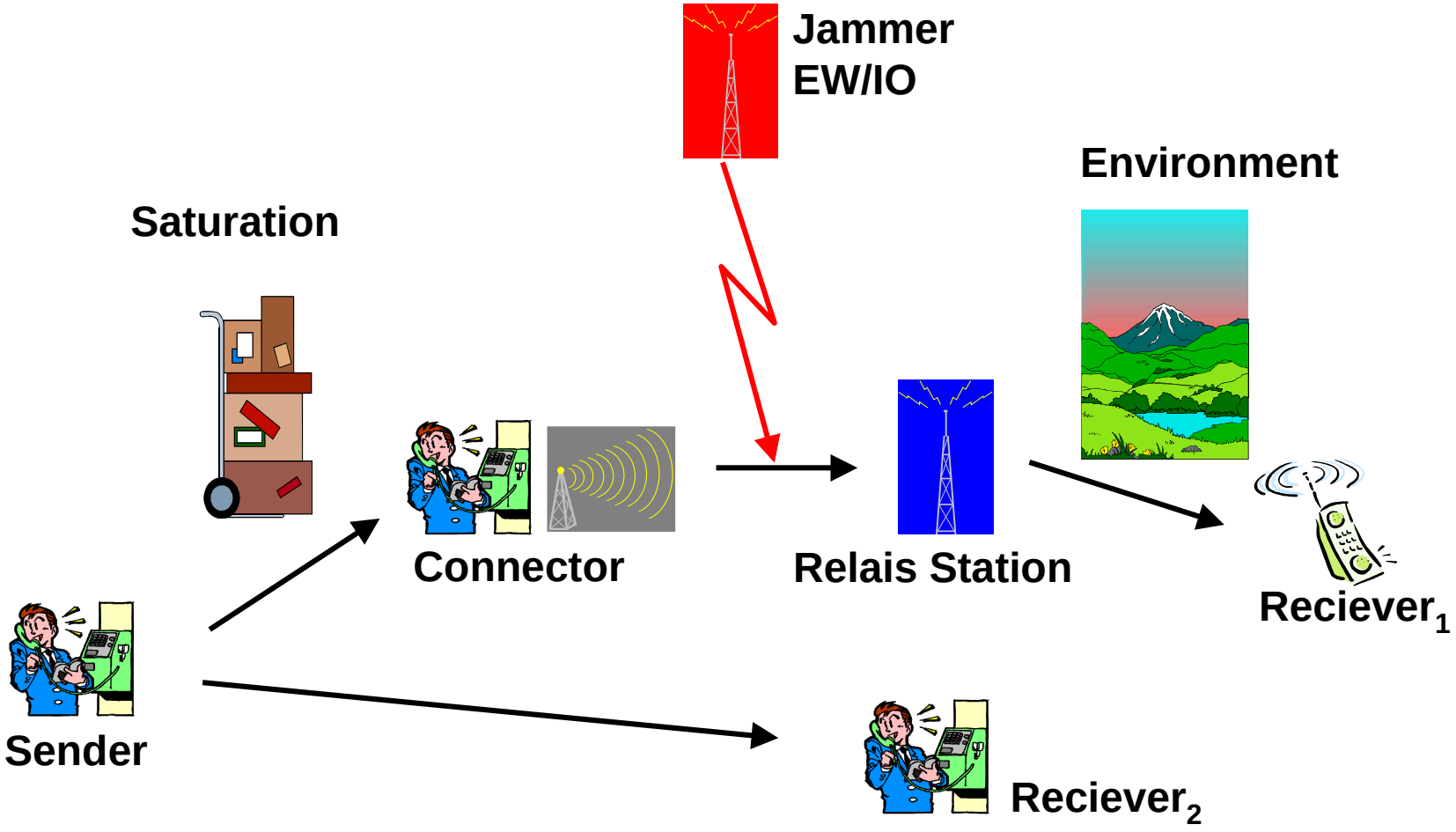
C2 Assessment using the German SimSys FIT

SimSys Architecture



C2 Assessment using the German SimSys FIT

Use of Communications Network



C2 Assessment using the German SimSys FIT

- **Command and Control Analyses**
  - + Time Constraints / Resources
  - + Ground Truth versus Perception
  - + Available versus Needed Information
  - + Effect of EW/IO
- **Communications Analyses**
  - + Information Relation Analyses
  - + Available versus Needed Capacity
  - + Influence of Information on Combat

C2 Assessment using the German SimSys FIT

Summary

- **FIT allows the user to design Command Posts on all Military Levels**
- **FIT enables to take into account**
  - + Human behavior
  - + Organizational Issues
  - + Communications (interior and exterior)
- **FIT is unique in the complexity as well as the offered functionality**
- **FIT is HLA compliant**